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Three-dimensional Modelling of Lithospheric-scale Structures of South Australia.

Integrated Geological and Geophysical Modelling

There are many software packages designed to create three-dimensional geological models. It is not uncommon to find modelling packages specifically developed within a particular market, such as mine planning or seismic and basin analysis. The strengths and weaknesses of each usually reflect its origin. It has been necessary within the course of this investigation to combine the capabilities of more than one of the standard geology packages, which has involved using additional modules or 'plug-ins' developed in-house (Aillères, 2000). An approach involving the application of one geoscientific information system (MapInfo™) and three standard modelling packages (GM-SYS™, gOcad™ & Noddy™) was adopted.

GM-SYS™- 2D & 2 3/4D Modelling

The GM-SYS™ modelling system is a two-dimensional forward modelling program for calculating the gravity and magnetic response of a geologic model. The system allows for interactively creating and manipulating models to match the observed gravity and or magnetic data by; (i) changing the selected modelling parameters; and or (ii) by adjusting the model geometry. All geological bodies are modelled in the third dimension as dipping prisms of finite strike length in either 2 or 2 3/4 dimensions.

gOcad™ – Geological Objects Computer Aided Design

The gOcad™ modelling system is a data-based, three-dimensional modelling package that integrates external information through an object-oriented approach (Mallet, 1992). The three-dimensional modelling environment of gOcad™ allows representation and definition of sophisticated models that are topologically and geometrically consistent with many types of external geological information including, drillholes, level plans and cross-sections, seismic lines. The modelling framework allows for interactive manipulation, interpretation and visualisation of geological models comprising two basic model-types relevant to this investigation; (i) surface-type models representing geological and or structural boundaries; and (ii) grid-type models in which physical rock properties may be characterised in the defined model space. ***(Click here to view 3D gOcad™ model; VRML plugin available at http://www.parallelgraphics.com/)***

Noddy™

The Noddy™ modelling system is a knowledge-based, three-dimensional kinematic forward modelling package that evolves on information of an *a priori* level of understanding (Jessell, 1997b). The system allows for construction of conceptual geological models and calculations of a geophysical response (Jessell et al., 1993). The Noddy™ package enables the development of complex structural histories. A three-dimensional model can be constructed through the superposition of a series of deformations on an initial layer-cake stratigraphy. The potential field response of the modelled three-dimensional geometry can be calculated (Jessell et al., 1993; Jessell, 1997a).

Three-dimensional modelling procedure

The procedure for three-dimensional modelling of lithospheric-scale structures of South Australia in this investigation involves several stages. The modelling operation is depicted in Figure 3 and is briefly outlined below:

• *Stage 1 – 2 3/4D gravity modelling*: The first activity of this stage involves extracting gravimetric profiles from the South Australian Bouguer gravity field map and importing them into the GM-SYS™ software. External constraints such as rock outcrop and drillhole information from the South

Australian Geoscientific GIS dataset are then integrated to create a geological model for each profile.

• *Stage 2 – Surface modelling*: GM-SYS™ models are exported into formats compatible with gOcad™. The next phase involves the creation of opened or closed surfaces from the finite set of points generated from the GM-SYS™ models. The creation of a surface is strongly influenced by the set of control points, in which case, multiple scenarios must be examined to determine the best fit to both the data and geological understanding. The resultant surface model is built up gradually through interpolation between each profile, the effect of which provides a self-consistency test of the two-dimensional interpretations.

• *Stage 3 – Grid modelling*: This involves generation of a rectilinear grid model that encompasses the continuous volume of the gOcad™ surfaces. The volume elements within the grid model are directly analogous to the surface model and represent the in-fill volume of the generated polyhedra. From this three-dimensional model, a synthetic gravimetric field model is calculated through Noddy™ by assigning rock density values to the modelled regions.

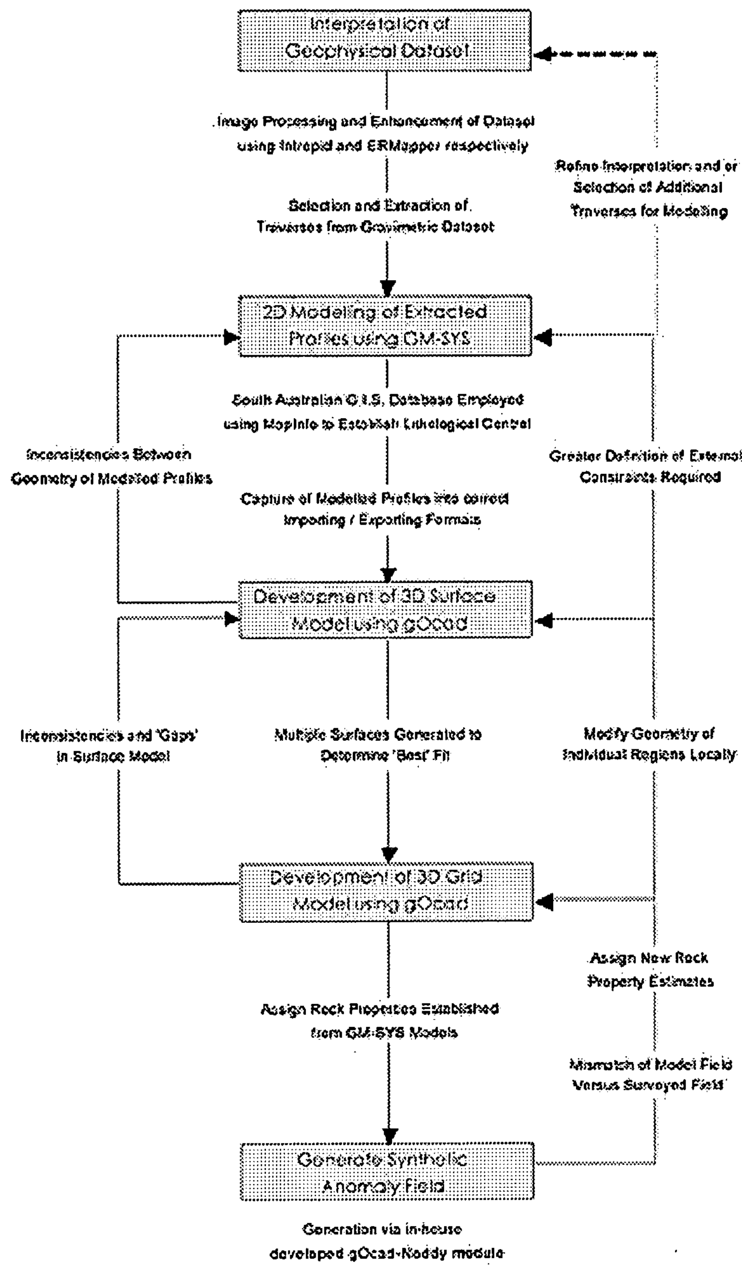

Figure 3. Schematic diagram showing the modelling operation used in this investigation.

Dominant Gravimetric Features

A number of relatively high gravimetric anomalies correspond to numerous crustal Palaeo- to Meso-proterozoic blocks (terranes) along the northern and western margins of the Archaean craton. These terranes have a distinctive gravimetric signature that can be mapped on the regional datasets and include the Mount Woods Inlier, the Peake and Denison Inlier, the Coober Pedy Ridge, the Mabel Creek Ridge and parts of the Ifould Complex (see Figure 2). A brief description and analysis of dominant gravimetric features of the Gawler Craton and its surrounds is given below.

Coober Pedy Ridge

The Coober Pedy Ridge is a large thrust-related, fault bounded elongated structural sliver of

continental crustal that lies unexposed in the northern central Gawler Craton (see Figure 2). This geophysically distinct terrane is characterised by a relatively high gravimetric anomaly that trends east-west and is cut by the regional-scale Karari Fault Zone (Rankin et al., 1989). The source of this regional feature may be attributed to the high iron content of supracrustal sequences comprising this crustal block (Finley, 1993; Betts, 1999). The abrupt boundary truncations of this gravimetric domain are manifested towards the northern and southern margins where they are defined by several different generations of folded thrusts (Betts, 1999). The consistently high amplitudes and short frequencies of this gravimetric feature reflect a relatively shallow-level source of the anomaly.

Mount Woods Inlier
The Mount Woods Inlier forms a geophysically discrete crustal block to the southeast margin of the Coober Pedy Ridge. It is characterised by a relatively high gravimetric response predominantly in the western domain from which a gradual easterly decrease in intensity is apparent (see Figure 2). This is attributed to an increase in the burial depth of the crustal block towards the east. The north-western boundary of this block and the south-eastern boundary of the Coober Pedy Ridge are separated by the east-west trending Cairn Shear (Betts, 1999).

Mabel Creek Ridge
The Mabel Creek Ridge is a predominantly polygonal-shaped crustal block situated immediately north of the Coober Pedy Ridge and is separated by the Mabel Creek Fault (Betts, 1999). The gravimetric signature of the Mabel Creek Ridge is dominated by a relatively moderate to high elongated, northeast trending anomaly in the south-western quadrant along the boundary with the Coober Pedy Ridge (see Figure 2). Towards the central and northern regions, the response is relatively low and is comparable in intensity to that of the background response of the Mulgathing Complex of the Archaean nucleus.

Peake & Denison Inlier
The Peake and Denison Inlier form an arcuate wedge of exposed Palaeoproterozoic metasediments and metavolcanics immediately adjacent to the north-eastern margin of the Gawler Craton (Flint, 1993b) (see Figure 2). The relatively high, internally varying gravimetric expression trends northwest and appears to form the northern part of a distinct broad northwest-southeast trending regional gravity anomaly that intersects the Stuart Shelf and parts of the north-western region of the Adelaidean Fold Belt.

Adelaidean Fold Belt
The Adelaidean Fold Belt outlines a continuous expanse of thick Neoproterozoic and Early Cambrian sedimentary sequences that extends from the south-eastern to central-eastern parts of South Australia (Parker, 1993a). The regional gravimetric response of the fold belt varies from relatively high to very high in the south and eastern regions to relatively low to moderate intensities in the central and north-western corner (see Figure 2). The western margin of the Adelaidean Fold Belt is defined by the curvilinear north-south trending Torrens Hinge Zone (Thomson, 1970), which is interpreted to represent the eastern margin of the Gawler Craton. The eastern and north-eastern margins of the fold belt are in spatial relation with the Curnamona Craton (Thomson, 1975) and associated supracrustal sequences of the Willyama, Mount Painter and Mount Babbage Inliers.

Gawler Range Volcanic Province
The central Gawler Craton exhibits a relatively low intensity, long wavelength and massive regional gravimetric anomaly in close spatial association with the Gawler Range Volcanics (see Figure 2). This relatively deep-level feature is suggested to represent a mafic body associated with underplating during partial melting of the lower crust (Creaser & White, 1991) and subsequent emplacement of the Hiltaba Suite Granitoids.

Fowler Orogenic Belt
The Fowler Orogenic Belt encompasses a large region of the western-central Gawler Craton and is predominantly composed of multiphase plutons of the Ifould Complex.

Hierarchical triangulation for multiresolution surface description

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↑ ABSTRACT

A new hierarchical triangle-based model for representing surfaces over sampled data is proposed, which is based on the subdivision of the surface domain into nested triangulations, called a hierarchical triangulation (HT). The model allows compression of spatial data and representation of a surface at successively finer degrees of resolution. An HT is a collection of triangulations organized in a tree, where each node, except for the root, is a triangulation refining a face belonging to its parent in the hierarchy. We present a topological model for representing an HT, and algorithms for its construction and for the extraction of a triangulation at a given degree of resolution. The surface model, called a hierarchical triangulated surface (HTS) is obtained by associating data values with the vertices of triangles, and by defining suitable functions that describe the surface over each triangular patch. We consider an application of a piecewise-linear version of the HTS to interpolate topographical data, and we describe a specialized version of the construction algorithm that builds an HTS for a terrain starting from a high-resolution rectangular grid of sampled data. Finally, we present an algorithm for extracting representations of terrain at variable resolution over the domain.

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